THE ROLE OF TRANSPORTATION COSTS ON AFFORDABLE HOUSING FOR LOW-INCOME CLASS

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Resume

This research was conducted to investigate the current state of transportation, as well as the transportation costs of the residents of towns with affordable residential houses, by preparing and presenting a questionnaire to these residents. In this questionnaire, things like housing costs, the amount of travel to the city center, satisfaction with public transportation services and its variety, easy access to public transportation and required places, the amount of use of public transportation and private vehicles were examined and solutions to reduce transportation costs were presented. Although the price of housing in the towns is lower than in the city center; the costs of transporting the residents of these towns are significant. In addition, the state of public transportation and access to needed places is unfavorable, so that about 60% of the interviewees were dissatisfied with public transportation services.

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1 Introduction

Housing and transportation are the two biggest categories of household expenses; Hence, they are the focus of majority of affordability analyses. However, since the transportation and land use have a close relationship with each other, it is not possible to create affordable housing without paying attention to transportation costs and the cheapness of land; because the cheap housing is usually in towns far from the city center and, if no measures are taken for transportation, the residents of these towns will bear huge transportation costs and finally, living in towns with cheap residential houses far from the city will not be economical due to transportation costs. Transportation constitutes the main spatial structure of cities and has fundamental effects on the shape and direction of urban development. Cities have complex transportation systems and these transportation systems give strength to cities. Therefore, paying attention to its affordability is of particular importance [1-2]. Affordability of goods or services means people's ability to buy basic goods and services. In recent research, it has been suggested that, to deal with the challenges of providing affordable public transportation services to poor urban residents at a cost that does not harm the financial-economic sustainability of the urban transportation system, city officials can set fares at "cost recovery" levels. appropriate, determine and target for the majority of the population and give subsidies to those who need them the most[3]. On the other hand, in 2010, transportation was the fourth category of household consumption (6.9%) for people who were in the lowest consumption sector (after food and beverages (41.5 %), housing (14.7%) and energy (8.1 %)), [4]. Lack of affordability can be the most important factor for the lack of access of the low-income class of the society to special transportation [5-6]. The affordability of transportation can be defined as the ability to make essential trips to work, school, health and other social services and to meet other family members or other urgent trips without restrictions resulting from economic issues [7]. Providing a definition of transportation poverty requires combining sub-concepts such as transport affordability, mobility poverty, accessibility poverty and exposure to transport externalities (Figure 1) [8].

In this regard, studies have been conducted in recent years; for instance, according to the research of Bagnoli et al., determining the affordability of transportation is

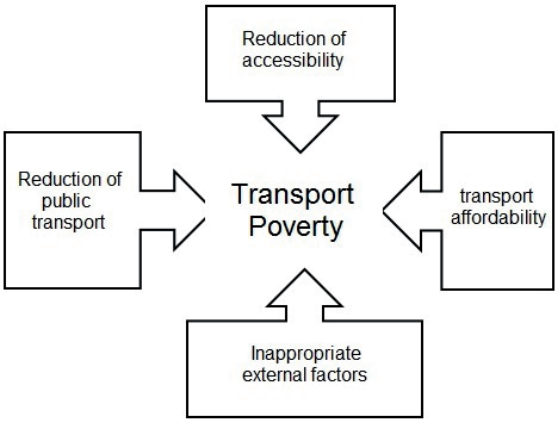

Figure 1 *Interrelationships between the dimensions of transportation poverty [8]*

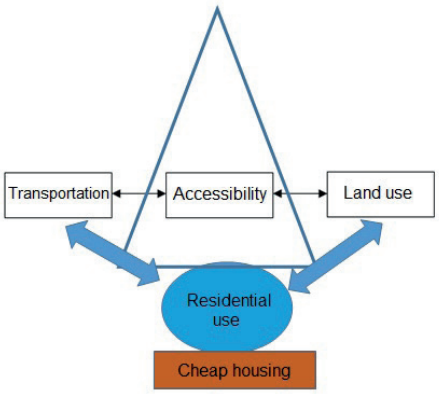

Figure 2 *Mediated accessibility between land use and transportation*

a complex process because while transportation needs are individual, income is a family characteristics, [9]. On the other hand, it is not possible to define a definitive criterion for determining affordable transportation for all the countries; although Srivastava [10] suggest that this criterion should be considered 15 to 20 % of household income for countries with developing economies. Guarda et al. in a 2016 study [11], stated that in the field of measuring transportation costs, the affordability of transportation for low-income groups may not show for the two reasons. First, there is more fare evasion in deprived areas. Second, poor people may avoid some motorized trips because they are too expensive. In this regard, authors found that fare evasion in Santiago is more frequent in bus stations located in low-income areas than in high-income areas, which shows that there is a relationship between fare evasion and inability to pay bus fare. On the other hand, the studies of Falavigna and Hernandez [12] and Behrens and Vente [13] show that in some poor parts of the city, walking accounts for 40 to 45 % of all the trips by the low-income people, while this value is 10 to 20 % for the higher income groups. These findings are important for designing transportation policies that benefit low-income groups. Rodriguez et al., in a study on the experiences of Latin American cities in promoting bicycles as a means of daily transportation [14], state that the main goal of affordable policies is that people can make all the necessary trips to access education, health, work and social services without forcing them to ignore essential activities. In fact, affordable policies have two main effects on mobility patterns. First, they can encourage greater use of public transportation. Second, they can facilitate switching from walking to public transport over long distances, although this effect is often small. In other words, to the improve transportation conditions for poor people, the authorities should invest in walking, cycling and public transportation facilities. It should be noted that public transportation has a special place [15], because public transportation systems have the greatest impact on urban development and provide the possibility of providing a situation for “combination of land use” and “public transportation”.

Transportation and housing have a close relationship with each other [16-17]; accessibility is a fundamental concept that expresses the basis of the relationship between the land use and transportation (Figure 2) and refers to the ease of moving between places; because when transportation becomes cheaper in terms of money and time, access will increase [18-19]. The person’s accessibility is usually measured by counting the number of activity places (opportunities) that are available at a certain distance from the person’s home and multiplying that number by the distance (Equation (1)) [20-21]. This capability can be calculated for all the kinds of opportunities from shopping, work, training etc. In fact, it can be said that the four main components of accessibility include land use, transportation, time and the needs and abilities of community members (Figure 3). In addition, this relationship can be presented in the form of Equation (2) [22].

$$A_i = \sum_j O_J d_{ij}^{-\beta}, \tag{1}$$

$$A_{total} = \frac{1}{N(N-1)} \sum_{i \neq j}^{N} \sum_{j=1}^{N} \alpha_{ij}, \tag{2}$$

where is:

A_i : The accessibility of person I,
O_J : The number of opportunities at a distance d from the person’s home,
d_{ij} : A measure to measure the size of the separation between i and j,
β : A fixed value that is obtained by paying the model,
A_{total} : access to different places,
α_{ij} : travel time between two places i and j are in this relationship.

Therefore, nowadays planning for affordable housing with development policies that include the effects of transportation is very important and since housing is the biggest expense of most households, the importance

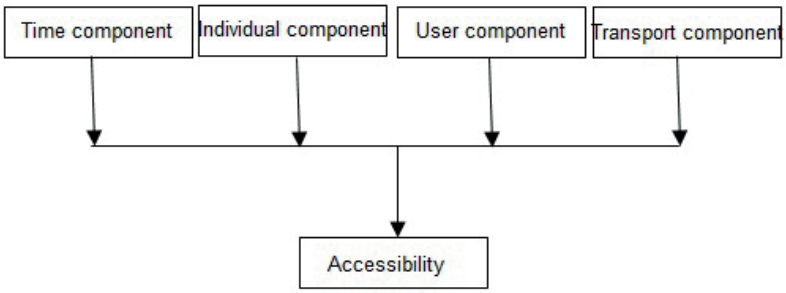

Figure 3 *Components of accessibility*

of this issue is doubled. Considering the general goals of providing affordable housing in areas with proper access and transportation options, there is a need to reduce unnecessary costs caused by the possible overestimation of car travel and its related effects [23] .Determining the affordability of housing is a complex process, just like determining the affordability of transportation. Housing affordability was initially defined as households not spending more than 30 % of their budget on housing; but since the costs of housing and transportation are interdependent, many experts recommend that housing affordability is defined in such a way that the housing and transportation costs of a household are at least 45 % of their budget. This shows that a cheap house is not really affordable if it has a high transportation costs. In this regard, experts suggest a more compact and multifaceted development of the city by reducing the distance between destinations and improving the options of non-motorized modes of transportation and modes of public transportation, which improve the overall accessibility, especially for pedestrians or public transportation passengers and as a result, living in a central urban neighborhood increases the variety of services and activities available at a given time and financial budget and in addition, it saves travel time and travel costs [24]. In this regard, Newmark et al. in a research in the field of affordable housing [25], state that the provision of affordable housing is influenced by proper location because the provision of affordable housing is influenced by the transportation costs. In fact, for the construction of affordable housing, high-efficiency neighborhoods, that is, places that meet the needs of residents with the lowest transportation costs, should be selected or created. High-level efficient places enable residents to drive less by making shorter trips or by using cheaper transportation modes such as walking and biking and as a result, residents' transportation costs are significantly reduced. In a 2020 study, Xiaohong et al. [26] also stated that social justice can potentially be improved by well-designed transportation systems. However, this is despite the fact that transportation facilities and systems are usually lacking and weak in towns where the land and housing are cheaper, which imposes high transportation costs on this low-income group. Abd El-Hameeda et al. consider one of the transportation problems in Egypt to be the lack of attention to urban planning and transportation issues and transportation costs [27].

As mentioned, transportation costs have a significant impact on housing costs, so that it is not possible to create affordable housing without paying attention to the transportation costs and the cheapness of the land. Therefore, this study and investigation of the transportation situation of towns deals with the preparation and completion of the questionnaire, as well as with solutions to reduce transportation costs for the low-income people and to create cheap housing with low transportation costs are introduced.

2 Research methodology

As mentioned, it is impossible to provide affordable housing for low-income people regardless of transportation costs. It is possible that cheap housing is usually located on the outskirts of cities and towns adjacent to the city and is far from the city center; therefore, if a suitable plan to provide cheap transportation for these areas is not considered, the residents of these areas will have to pay huge costs to meet their needs and access to the city center. Therefore, to check the current situation of transportation of the residents of towns, a questionnaire was prepared and provided to the residents of towns. This questionnaire includes questions about the costs of housing, the amount of travel to the city center, satisfaction with public transportation services and its variety, easy access to public transportation and required places, the amount of use of public transportation and private vehicles. In order to analyze the factors affecting this research, a statistical test was performed using the KMO (Kaiser-Mayer-Okine) method, the results of which are presented in Figure 4 and Table 1. According to Figure 4 and Table 1, only four primary factors have the greatest effect and the rest of the variables have similar and small effects.

In continuation of the research, the answer sheets were evaluated using the SPSS software. In addition, in this research, the countries that were successful in this field are examined and finally, it offers suggestions in this regard. The countries investigated in this field include Turkey, Brazil, Taiwan, America, England, Egypt and Australia.

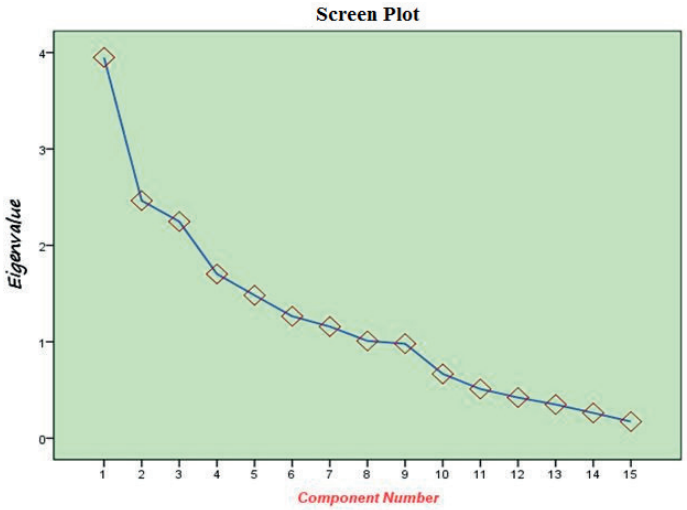

Figure 4 *Chart of specific values of the number of factors extracted in this study*

Table 1 *Extracted factors along with specific values, % age of variance and cumulative % age of variance*

Component	Question subject	Cumulative %	% of Variance	Total
1	Housing costs	21.190	21.190	3.949
2	The amount of travel to the city center	34.411	13.221	2.464
3	Transportation costs	46.466	12.055	2.247
4	Satisfaction with public transportation	55.604	9.138	1.703

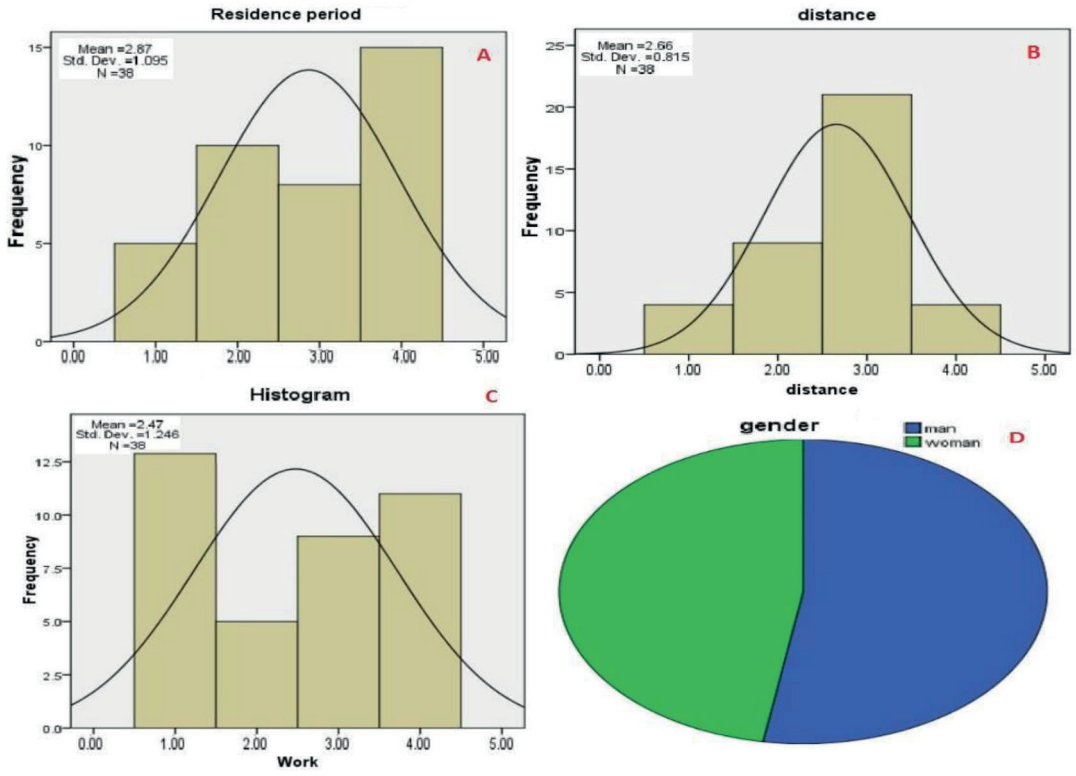

Figure 5 *Frequency diagram related to: a - Duration of residence in the town; b - The distance of the town from the city center; c - Type of work; d - Gender of people.*

3 Results and discussions

As mentioned, to check the existing transportation situation of the residents of towns, a questionnaire was prepared and given to the residents of towns and then the answers were evaluated using the SPSS software. In Figure 5, the graph of the frequency data related to the characteristics of the people completing the questionnaires and in Figure 6 and Figure 7 the graph of the frequency data of the answers are presented.

According to Figure 5, most of the people who participated in completing the questionnaires have been living for a long time (more than 8 years) in towns with more than 10 kilometers from the city center and most of them are employees. According to Figure 5-d, about 47.4 % of people are women and 52.6 % are men.

According to Figure 6, it can be seen that in the current situation, although the price of housing in the towns with affordable and low-costs residential houses is lower than in the city center; the costs of transporting the residents of these towns is significant and the public transportation and access to the required places are also unfavorable. For example, according to Figure 2-d, most of the residents were dissatisfied with public transportation services and according to Figure 2-i, most of the residents do not use public transportation due to dissatisfaction with transportation services.

In general, there are two ways to improve the transportation situation and reduce the transportation costs of the towns' residents. The first solution is to create places needed by the towns' residents, such as supermarkets, hospitals, etc. in the towns, which reduces the need to move to the city center. The second solution is to increase the variety of public transportation and improve their services, which is discussed in the next section.

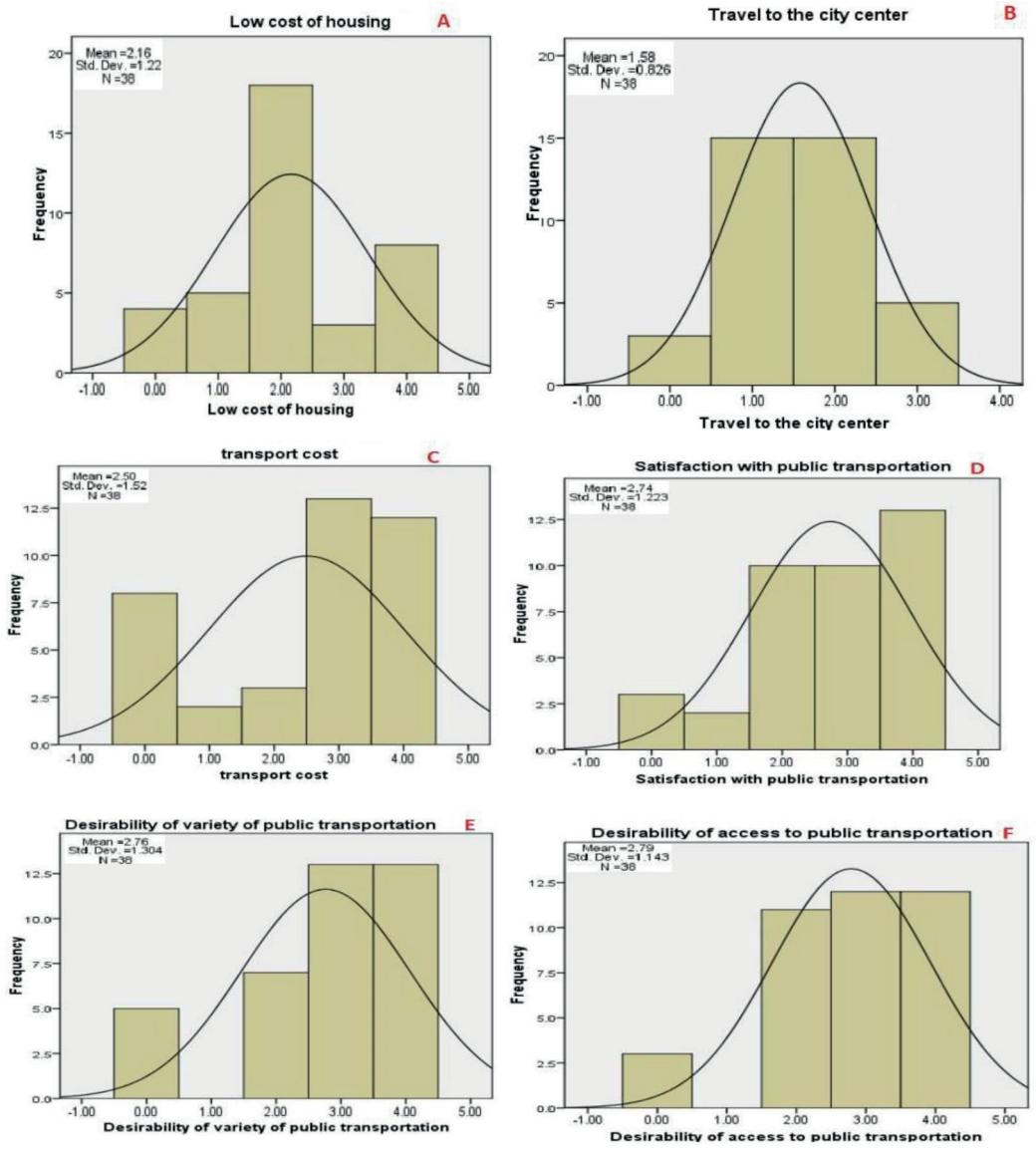

Figure 6 *Frequency diagram related to answer to:A - Question 1; B -Question 2; C - Question 3; D - Question 4; E - question 5; F - Question 6.*

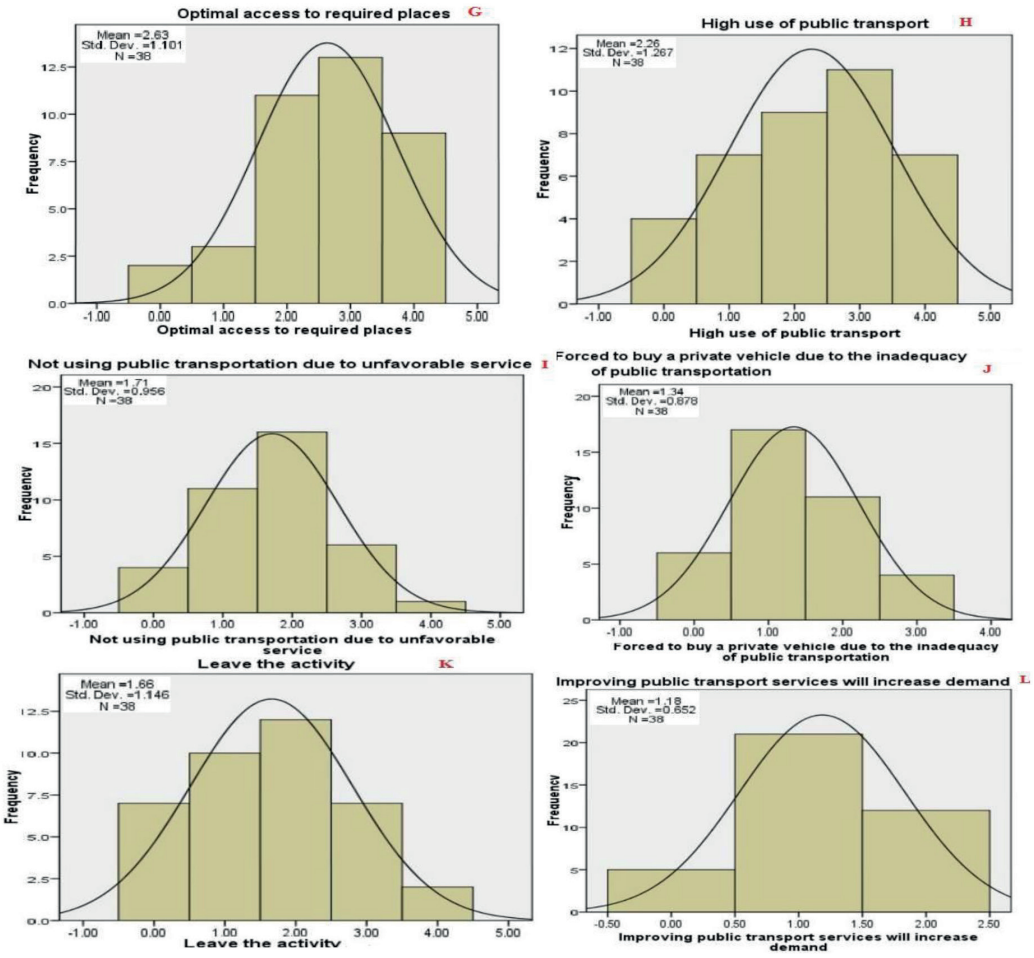

Figure 7 *(Continuation of Figure 6) Frequency diagram related to answer to: G - Question 7; H;-;Question ; I - Question 9; J - Question 10; K - Question 11; L - Question 12.*

Table 2 *Suitable transportation systems for the low-income class in different countries*

Transportation modes	Country
Bus-Dolmus- Metro and Tram- Metrobus	Turkey
Bicycle-Bus-Metro-Taxi	Brazil
Metro (MRT) - City bus - Public bicycles	Taiwan
Metro-Bus-Tram-Taxi	America
Bus - Metro - Docklands Light Rail (DLR) - Water Bus - Local Trains - Public Bikes - Taxi - Tram - Air line Cable Cars	United Kingdom
Bus-Taxi-Minibuses-Metro	Egypt
Metro-Bus-Tram-Taxi-Bicycle	Australia

4 Solution to reduce the transportation costs for towns with affordable residential houses

As mentioned, one of the ways to reduce the transportation costs for the low-income class is to increase the variety of public transportation and improve their services. In Table 2, urban transportation modes, used in countries successful in this field, are presented.

The bus transportation system is one of the most popular and cheapest urban transportation systems, which can be considered the main type of ground transportation. The transportation costs by bus in the mentioned countries are very economical and considered as one of the cheapest modes of transportation (Figure 8-A). The use of modern and standard buses with high comfort facilities in these countries has attracted many passengers to this mode of transportation. The BRT is a bus-based public transportation system designed to improve capacity and reliability over conventional bus systems. In the United States, several medium-

A *B* *C* *D* *E* *F* *G* *H*

Figure 8 *A - Bus transportation system; B - Double-decker bus; C – Dolmus; D - Metro and tram; E - Aerial tram; F – Metrobus; G - Docklands Light Railway; H -Airline cable cars*

sized cities have replaced BRT with light rail. In addition, London's iconic double-decker buses are a fast, comfortable and cheap way to travel around the city and create many opportunities to see London sights along the way (Figure 8-B).

Dolmuses are actually buses whose size is smaller than regular buses and their use is faster and more comfortable. 10 to 15 passengers can ride in these dolmuses. The costs considered as a ticket for this vehicle are very low (Figure 8-C).

Metro and tram are one of the best and most economical means of transportation in Turkey. This method of transportation is very fast and efficient and is used to move people in different parts (Figure 8-d). It should be noted that there is an interesting type of tram in New York, which is aerial, which runs along the

East River of Roosevelt Island. This type of tram was opened as the first aerial tram in North America in 1976 (Figure 8-E).

Metrobus is actually the name given to the buses that work in the subway format. Metrobuses are used for fast transportation in the city. Of course, in many of these routes, metrobuses are connected to other public transportation vehicles. With this integration, passengers can easily access different means of transportation and reach their destination easily (Figure 8-F).

Contrary to the thinking of some people who consider using a bicycle as just a hobby or a sport, bicycle is an effective and common mode of public transportation in cities. Using the bicycle sharing method in cities is considered as an important method for commuting inside the city. The citizen bike-sharing program first started in Rio de Janeiro, a city in Brazil, but in less than 10 years it has spread across the country.

Another common mode of transportation in cities is using a taxi. Although commuting by taxi can reduce the travel time, its costs are higher than for other modes of transportation.

The innovative and unmanned Docklands rail system covers London's East and South East London rail system (Figure 6-G). With the use of water buses, one can access the main areas of the England capital very quickly and one can also enjoy the beauty of the river Thames while moving. London's local trains are in close correlation with the subway lines, but the route of these trains is more extended than the underground railway lines and they provide people with the ability to access areas far from the subway.

Airline cable cars is a mode of transportation that has been implemented in the city of London. With the airline cable cars, one can enjoy the beautiful views of the city while moving around the city. Airline cable cars are an easy way to get around the Greenwich Peninsula. The journey with aerial cable cars takes about 10 minutes. Cars with a capacity of 10 people arrive at the station every 30 seconds (Figure 8-H).

4.1 Comparison of suitable transportation systems for the low-income classes in different countries

In general, most of the countries have expanded various modes of public transportation to ensure social justice in transportation and to provide transportation infrastructure for the low-income classes, as well as to reduce traffic pollution and they encourage people to use the public transportation by implementing policies that limit personal motorized transportation and, on the other hand, increase the possibilities of public transportation modes and make it cheaper. The development of a diverse set of public transportation means, with appropriate and cheap facilities, provides the possibility of moving the low-income classes efficiently, while maintaining social justice and this is while neglecting different modes of public transportation, or not improving its facilities and instead of paying too much attention to personal motorized transportation and creating multiple infrastructures for it. In addition to causing various pollutions, including visual, noise and air pollution in the cities, social justice is questioned and the citizenship rights of the low-fashion classes are ignored.

According to the above mentioned modes of transportation, buses, minibuses, subways, trams with suitable facilities, similar to the mentioned examples, can be a suitable option for the transportation of the low-income classes and reduce the transportation costs related to low-income classes, which is usually built on the outskirts of cities and far from city housing and help create a real affordable housing.

5 Conclusions and suggestions

Since the transportation and land use have a close relationship and that it is not possible to create affordable housing without considering transportation costs and the cheapness of land, this research was conducted to investigate the current state of transportation, as well as the transportation costs of the towns' residents with affordable residential houses by preparing and presenting a questionnaire to these residents. In this questionnaire, things like housing costs, the amount of travel to the city center, satisfaction with public transportation services and its diversity, easy access to public transportation and required places, the amount of use of public transportation and the personal vehicle was analyzed, and some of its results are summarized below:

According to the statistics conducted, in the current situation, although the housing prices in towns are lower than in the city center, the costs of transporting the residents of these towns are significant and the public transportation and access to the required places are also unfavorable.

The results of the survey clearly show that the inadequate access to public transportation means and their lack of diversity and the inappropriateness of amenities, public transportation services and, most importantly, the large distance between them, cause the residents of the studied towns to be reluctant to use the public transportation. It should be noted that the results of the survey show that more than 86 % of the interviewees believe that with the improvement of public transportation services and conditions, the demand and willingness to use public transportation will increase.

The reluctance to use public transportation due to the problems in the public transportation system of the towns has caused the residents of these towns to use personal transportation or taxis to move to the city center and carry out their activities, which has resulted in a lot of costs. Therefore, creating a coherent

set of public transportation modes with facilities and reasonable prices can be a very effective solution to reduce the transportation costs, especially in towns and far from the city center.

By identifying the usual needs of a citizen, the urban layout should be such that in every neighborhood and town, citizens can reach the place they need to meet their needs by traveling a short distance. For example, they can reach schools, clinics, stores, etc. by walking a short distance.

Another way to reduce travel and, as a result, reduce the transportation costs is to improve telecommunication and internet facilities in cities and especially towns; because with telecommunication services, many things can be done offline and virtually and there is no need to move and pay for it.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Questionnaire used in this research.

Number	Question	Completely agree	Relatively agree	No idea	Relatively	Against	Completely opposed
1	The costs of housing in the town where you live is lower than in the city center.						
2	You travel to the city center due to daily needs and high employment.						
3	The transportation costs from your place of residence to the places you need are less than in the city center.						
4	You are satisfied with the public transportation of the place of residence to access the city center.						
5	The variety of types of public transportation is suitable in the town where you live.						
6	Access to public transport in your town is very easy.						
7	In the town where you live, it is easy to access all the necessary places, such as supermarkets, hospitals etc. and there is no need to go to the city center.						
8	You use public transportation a lot.						
9	Due to the inadequacy of amenities and the large distance from public transportation you do not use public transportation to get around						
10	Due to the inadequacy and lack of public transportation services and the lack of access to the required places, you have to buy a personal vehicle.						
11	Due to inappropriate transportation services and distance from the city center, forced to give up job or educational, recreational and sports activities.						
12	It is believed that with improvement of the public transportation conditions, there is no need for a private car anymore and the demand is related to public transportation will increase.						